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Development of Valleys in the Escarpment Zone of the Roztocze

Rozwój dolin w strefie krawędziowej Roztocza

Развитие долин в зоне краевого уступа Росточа

The southern scarp of the Roztocze, clearly differentiated by its relief and geological structure, corresponds to an important geological limit considered as the marginal zone of the Carpathian Foredeep. That is why it has been the object of interest of geologists and geographers for a long time (Nowak 1922, Samsonowicz 1925, Pawłowski 1938, Jahn 1956, Maruszczak i Wilgat 1956, Buraczyński 1967, 1974a, Ney 1969b).

The escarpment zone of the Roztocze was developed on the line of old structures, as it is indicated by the recent geological studies (Ney 1969b, Pożaryski 1974, Żelichowski 1972, 1974). In this area the tectonic line separates two structural units of the Radom—Kraśnik Uplift from the Carpathian Foredeep. The zone separating these units has been intersected by Bretonian and Laramian dislocations of the NW—SE direction. The contemporary tectonic image of the Roztocze developed as a result of the Tertiary rejuvenation of faults, the development of fault steps (NW—SE) and of the concomitant longitudinal and transversal rift (Jaroszewski 1977). The marginal zone of the Roztocze was developed in Miocene as a result of synsedimentary tectonics connected with the formation and filling of the Carpathian Foredeep (Areń 1962, Bielecka 1967, Muchowski 1970, Ney 1966, 1969a).

The essential characteristics of the relief in the escarpment zone are connected with the lithological differentiation of the Miocene deposits and tectonics. Its further development was connected with the Quaternary tectonics, as indicated by geomorphological (Pawłowski 1938, Jahn 1956, Maruszczak i Wilgat 1956, Buraczyński 1967) and geological studies (Nowak 1922, Ney 1969a, Ruhle 1969). Recent studies indicate the occurrence of early Quaternary tectonic movements in the escarpment zone (Kowalski, Liszkowski 1972, Buraczyński 1974a, Harasimiuk, Henkiel 1975, Kowalski 1975, Malinowski 1977, Laskowska-Wysoczańska 1979). Pawłowski (1938) and Jahn (1956) present the main elements of the geological structure and the relief of the escarpment zone. Maruszczak and Wilgat's (1956) investigations concern the escarpment zone of the Roztocze Tomaszowskie, and Buraczyński's (1967, 1968, 1974a, b) relate to the Roztocze Gorajskie and Roztocze Rawskie.

QUATERNARY

The Tertiary surface in the escarpment zone of the Roztocze has a diversified relief connected with the occurrence of fault steps and the fossil valleys. In the area of the Sandomierz Basin, along the scarp of the Roztocze, the Tertiary surface can be observed on 175—200 m a.s.l., in the fossil valley of the Gorajec in Biłgoraj on 120 m a.s.l., and in Hedwiżyn — 150 m a.s.l. (Buraczyński 1967, 1974a, Laskowska-Wysoczańska 1979).

The irregularities of the Tertiary surface are covered by Quaternary accumulations — sands, silts, till and fluvioglacial, as well as fluvial, flood-water, slope accumulation and aeolian deposits (Bielecka 1960, Buraczyński 1967, 1974a, Racinowski 1969).

The development of the relief of the Roztocze as well as climate changes are reflected in the sediments deposited in the foreland of the Roztocze. Learning more about the Quaternary formations of the Sandomierz Basin is therefore important for the reconstruction of the detailed history of the development of the Roztocze. The Quaternary formations constitute a continuous cover of changeable thickness (30—80 m). The fullest profile of these formations has been discovered in the fossil valley of the Gorajec in the Roztocze (Buraczyński 1967), which constitutes a fragment of the pre-San valley from the oldest Pleistocene (Klimaszewski 1958, Rühle 1967). Its continuation in the Sandomierz Basin is the fossil valley discovered in Biłgoraj. It is a valley 80 m deep, filled in the base with a fluvial series dated by Buraczyński (1974) to come from the Tegelian Interglacial (Fig. 1). In the fossil valley of the Wieprz near Łęczna Harasimiuk and Henkiel (1980) have discovered gravels of the Miocene and Jurassic limestones in

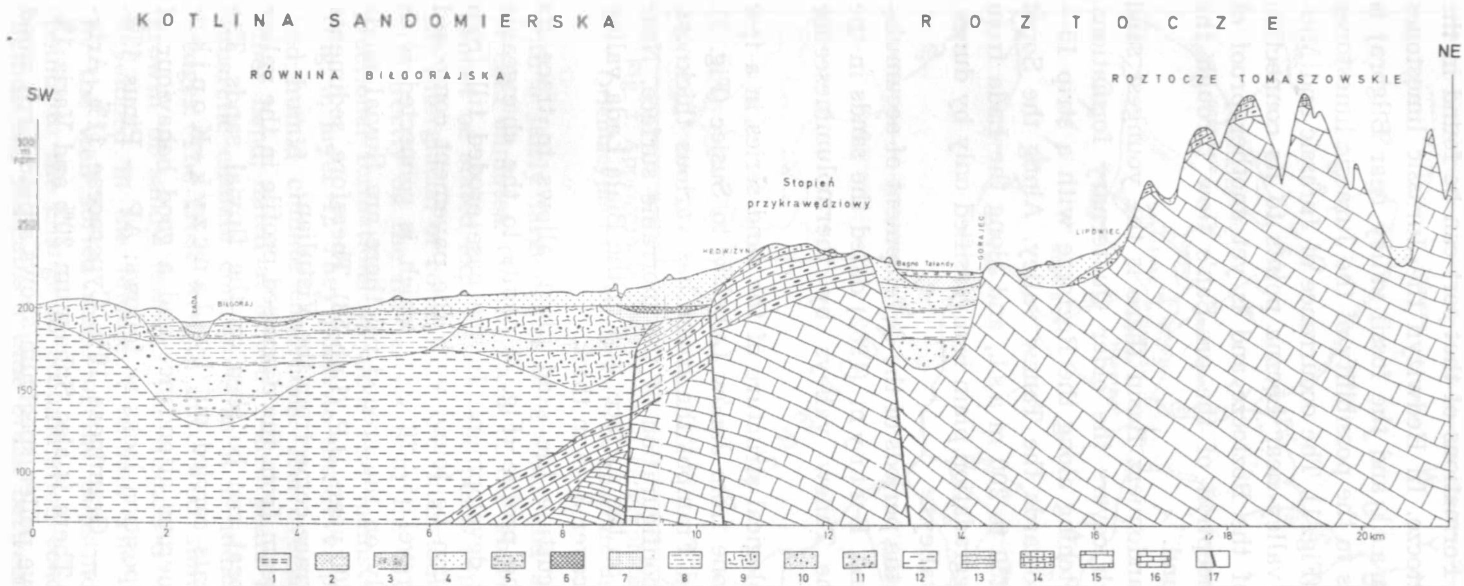


Fig. 1. Geological section of the edge zone of the Roztocze (after B u r a c z y ń s k i 1974a); 1 — peats (Holocene), 2 — fluvial sands (Holocene), 3 — dune sands (late Vistulian), 4 — fluvial and slope sands of the Sandomierz Basin (Saalian and Vistulian glaciation), 5 — sands with gravels (Saalian glaciation), 6 — peats (Great interglacial?), 7 — fluvial-limnic deposits (Great interglacial?), 8 — silts (Great interglacial), 9 — till (Elsterian glaciation), 10 — fluvioglacial sands (Elsterian glaciation), 11 — fluvial sands with limestone gravels (Tegelen), 12 — Krakowiec clays (Sarmatian), 13 — sands and detrital limestone (Badenian), 14 — Lithothamnian limestones and sandstones (Badenian), 15 — gaizes and marls (Campanian and lower Maastrichtian), 16 — dolomites and limestones (Jura), 17 — faults

Przekrój geologiczno-morfologiczny przez strefę krawędziową Roztocza (według B u r a c z y ń s k i e g o 1974 a); 1 — torfy (holocen), 2 — piaski rzeczne (holocen), 3 — piaski wydmowe (schyłek glacjału), 4 — piaski rzeczne i zboczowe, utwory zasypania Kotliny Sandomierskiej (zlodowacenie Saalian i Vistulian), 5 — piaski ze żwirami (zlodowacenie Saalian), 6 — torfy (interglacjał wielki?), 7 — piaski pylaste rzeczno-jeziorne (interglacjał wielki?), 8 — mułki (interlgacjał wielki), 9 — glina morenowa (zlodowacenie Elsterian), 10 — piaski fluwioglacjalne (zlodowacenie Elsterian), 11 — piaski ze żwirami kredowymi (interglacjał tegelen), 12 — iły krakowieckie (sarmat), 13 — piaski i wapienie detrytyczne (baden), 14 — wapienie litotamniowe i piaskowce (baden), 15 — opoki i margle (kampan i mastrycht dolny), 16 — dolomity i wapienie (jura, malm), 17 — uskoki the oldest fluvial sediments. Formations of that sort can be found in the escarpment zone of the Roztocze. In Hedwiżyn the Jurassic limestones occur at the depth of 125 m a.s.l. and the fossil valley near Biłgoraj is cut to 120 m a.s.l. This points to the possibility of the Jurassic limestones getting to fluvial sediments (Fig. 1). The occurrence of Jurassic and Miocene gravels in the Wieprz valley near Łęczna points to its connection with the escarpment zone of the Roztocze and is yet another proof of Pawłowski's (1938) conception of the pre-San's flow through the Roztocze and the Lublin Upland.

On the surface of the Sandomierz Basin there is the youngest sand series (5—20 m thick) which covers the older Quaternary formations. The sands build a plain stretching along the Roztocze with a strip 15—25 km wide and lowering towards the Tanew valley. Along the Sopot valley its height falls from 250 to 200 m a.s.l., and along the Łada from 220 to 190 m a.s.l. The flat aggradation plain is diversified only by dunes, deflational basins and river valleys.

In order to acquaint with the periods of the development of accumulation plain on Roztocze foreland Butrym (1982) dated the sands in the profiles of the Łada and the Tanew valleys by thermoluminescence analysis.

I have recognized the geological structure of the sand series in a few profiles of the escarpment zone from Janów Lubelski to Susiec (Fig. 2). Between Janów Lubelski and Frampol the cover has various thickness. This is connected with the configuration of the morraine surface. Near Dzwola till occurs in patches on the surface, and in the Biała Łada valley it is exposed under the sand cover 3—5 m thick.

The Biała Łada valley, cutting the sand plain, allows to trace its structure near Niemirów. The profile (Fig. 3) points to the changeable conditions of the sand cover development. In the base eroded till from the South Polish Glaciation can be found with the pavement composed of crystalline and marble gravel (5—20 cm), which is connected with the erosional activity. Directly on the eroded till there are fluvial sands (layer 5), dated at 46 800 ± 5600 years B.P. (Lub-58). Therefore, sediments which constitute the Łada terrace come from the Vistulian.

One kilometer away upstream from the discussed profile in the valley side a 30 cm thick bed of peat can be seen on the fluvial sands. The palynological expertise of peats carried out by Janczyk-Kopikowa (1972) has shown a numerous attendance and a good behaviour of pollen and spores. Their composition looks as follows: AP — Pinus 43%, Betula 31%, Picea 1%; NAP — Gramineae 10%, Cyperaceae 11%, Artemisia 2%, Ranunculaceae 2%. There is also Sphagnum 20% and Varia 1%, not counted in 100%. The above pollen spectrum shows a pine-birch wood

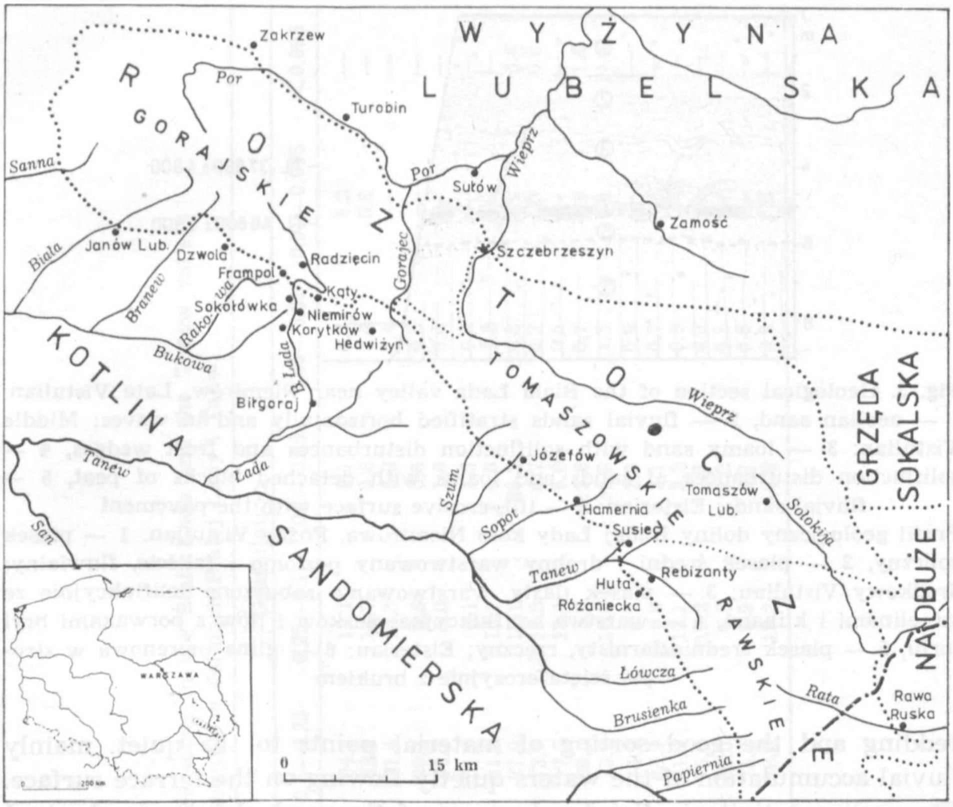


Fig. 2. Approximate disposition of geographical names occurring in the text
Orientacyjne rozmieszczenie nazw geograficznych wymienionych w tekście

with a fairly large share of grasses and sedges which is characteristic of cold climates. On the basis of the above data and geological facts it cannot be stated explicitly if the peats represent the decadent phase of the Interglacial or come from the Interstadial.

Directly on the fluvial sands of the discussed profile there are solifluctional formations of sands and loams with detached blocks of peat (Fig. 3, layer 4). They point to the development of accumulation in cool and humid climate conditions. The overlaying sands (layer 3), on the other hand, dated at 37 600 ±4800 years B.P. (Lub-57) were formed in subarctic climate conditions as it is indicated by the syngenetic frost wedges. The frost wedges developed simultaneously with the gradual growth of sandy terrace. The discussed sands and silts (layers 3—5) developed in the Middle Vistulian. The second layer is constituted by the well sorted sands of the indistinctly undulating bedding. This points to the change in accumulation conditions, and the discontinuous humus bed indicates a time break between layers 3 and 2. The type of

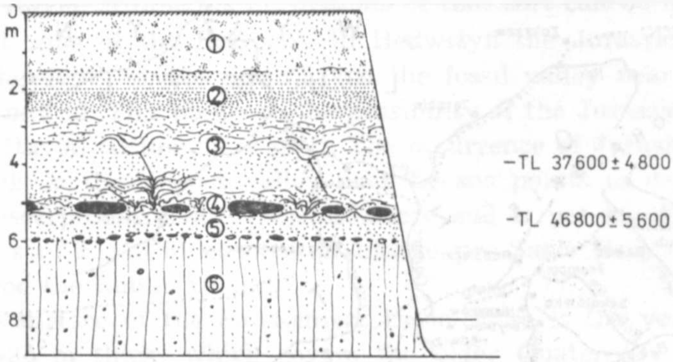


Fig. 3. Geological section of the Biała Łada valley near Niemirów. Late Vistulian: 1 — aeolian sand, 2 — fluvial sands stratified horizontally and in waves; Middle Vistulian: 3 — loamy sand with solifluction disturbances and frost wedges, 4 — solifluction disturbances of sands and loams with detached blocks of peat, 5 — fluvial sands; Elsterian: 6 — till, erosive surface with the pavement

Profil geologiczny doliny Białej Łady koło Niemirowa. Późny Vistulian: 1 — piasek eoliczny, 2 — piasek średni i drobny warstwowany poziomo i faliście, fluwialny; Środkowy Vistulian: 3 — piasek ilasty, warstwowanie zaburzone soliflukcyjnie ze szczelinami i klinami, 4 — warstwa soliflukcyjna piasków i iłów z porwakami brył torfu, 5 — piasek średnioziarnisty, rzeczny; Elsterian: 6 — glina morenowa w stropie ścięta erozyjnie z brukiem

bedding and the good sorting of material points to the quiet, mainly fluvial accumulation of the waters quietly flowing on the terrace surface. The aeolian activity in the development of the sand plain is emphasized by the dune.

The geological structure of the sandy plain suggests a complex origin and variety of processes involved. In the Biała Łada valley in the Roztocze the terrace represents mainly fluvial accumulation of the Vistulian. In Radzięcin it is composed of medium and an addition of fine sands, and in Wola Kątecka of well sorted medium sands (Table 1). Along the edge of the Roztocze the deluvial deposits can be found. Near Frampol they constitute a six meter series of bedded sands of the inclination of 2—8°. The sandy plain in the Sandomierz Basin has a complex origin and was formed by various processes. In the Biała Łada valley between Sokołówka and Niemirów the terrace is limited only to a narrow belt. To the west of the Biała Łada valley near Niemirów, there are flat sandy humps. They are limited by a distinct scarp and rise 5 m over the terrace. They are built of vari-size grained sands with pavement on the surface and frost wedges. They constitute residuals of the sandy plain of the Central Polish Glaciation. The analysis of the geomorphological map indicates the polygenesis of the sandy plain (Fig. 6). One can observe the insertion of the Vistulian sands into the older cover. R a c i n o w s k i

Tab. 1. Grain-size composition of terrace sands in the Biała Łada and the Tanew valleys
Uziarnienie piasków terasowych w dolinach Białej Łady i Tanwi

Profiles	Depth m	Granulation							
		2—1	1—0.5	0.5—0.25	0.25—0.1	0.1—0.05	0.05—0.01	0.01—0.005	<0.005
Łada — Radzięcin	2.5	—	7.6	64.3	12.1	8.1	6.7	1.2	—
	6.0	+	6.8	62.5	14.7	9.8	5.4	0.8	—
	8.0	+	6.9	71.4	14.3	6.0	1.4	—	—
Łada — Wola Kątecka	2.0	0.1	6.0	90.3	2.5	0.6	0.5	—	—
	6.0	+	3.3	90.3	5.0	1.0	0.4	—	—
Łada — Niemirów	1.6	2.9	37.6	51.5	6.1	1.5	0.3	—	—
	2.2	+	2.2	81.9	10.1	4.0	1.8	—	—
	2.7	—	3.2	27.9	17.1	29.2	14.8	1.2	6.6
	4.0	0.4	3.4	73.0	13.8	6.7	0.3	1.9	0.8
	5.5	+	2.6	77.5	13.4	6.0	0.5	—	—
	6.0	+	5.2	69.7	8.8	12.6	0.7	1.6	1.4
	7.5	1.5	4.9	13.2	16.6	36.9	11.5	2.3	14.6
Tanew — Huta Różaniecka	2.0	0.2	12.5	74.9	8.7	2.8	0.9	—	—
	4.0	0.3	21.1	68.9	6.9	2.1	0.7	—	—
	5.5	+	2.7	81.4	12.1	3.2	0.6	—	—
	10.5	—	1.0	75.6	15.2	7.3	0.9	—	—
	12.5	+	6.0	86.0	6.5	1.2	0.3	—	—
	14.0	+	11.6	75.3	9.9	2.7	0.5	—	—
	20.0	0.2	7.3	58.6	19.2	10.6	3.3	0.8	—

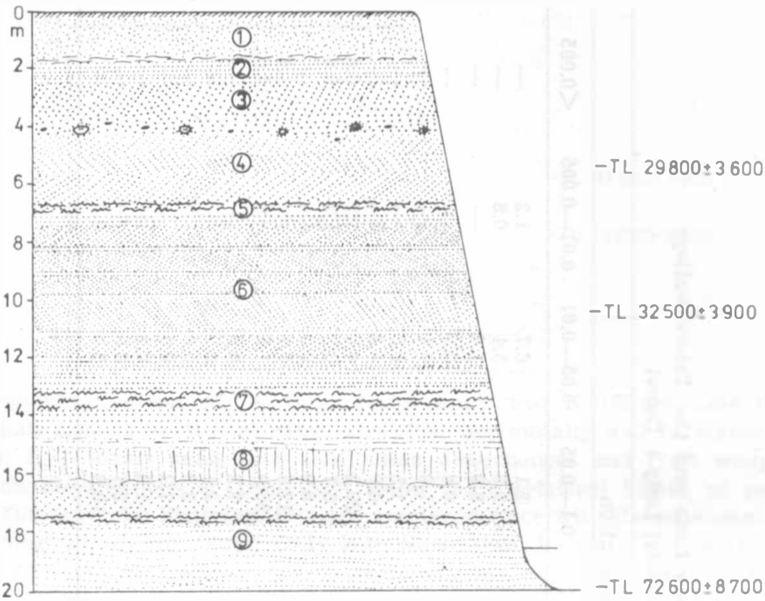


Fig. 4. Geological section of the Tanew valley near Huta Różaniecka (Fig. 9, section c). Late Vistulian: 1 — structureless sand, 2 — proluvial sand, 3 — stratified sand, inclined 10—20°, 4 — fine-grained sands stratified, inclined 0—15°, and at the back gravels and clay balls, 5 — silts, 6 — stratified sands, inclined 0—15°; Middle Vistulian: 7 — silts, 8 — sandy clay; Early Vistulian: 9 — medium and fine-grained aeolian sand well-sorted with silt bands, stratified, inclined 10°

Profil geologiczny doliny Tanwi koło Huty Różanieckiej (ryc. 9, profil c). Późny Vistulian: 1 — piasek średni, bezstrukturalny, 2 — piasek drobny, warstwowany, 3 — piasek gruboziarnisty, warstwowany, o nachyleniu 10—20°, 4 — piasek drobno i średnioziarnisty, warstwowany o nachyleniu 0—15°, w stropie żwiry krystaliczne i toczeńce ilaste, 5 — mułek warstwowany, 6 — piasek drobny i średnioziarnisty warstwowany 0—15°; Środkowy Vistulian: 7 — mułek, 8 — glina piaszczysta; Wczesny Vistulian: 9 — piasek średni i drobny dobrze wysortowany, eoliczny z przewarstwieniami mułku, warstwowany o nachyleniu 10°

(1969) noted the surface occurrence of sands of various lithological characteristics to the west of Korytków and dated them as coming from the Central Polish Glaciation age.

Often, however, the occurrence of elements of different ages on a sand plain is difficult to observe because the surface was cut on one level and covered by the sediments from the younger aeolian phase.

The sandy plain in the eastern part of the escarpment zone between Górecko and Huta Różaniecka has a similar structure. The valleys of the Szum, the Sopot, the Tanew and the Jeleń cut into the 10—20 m thick sand cover. It is composed here of medium grained sands covering fine siltous-grained sands. Only in the Sopot valley till has been found in the base. The complex structure of the sandy plain is characterized by the profile from the Tanew valley near Huta Różaniecka (Fig. 4). The position of this profile near the edge of the Roztocze (1 km), in a comparatively large valley, influenced the great activity of the accumulation processes.

The studied profile indicates the changeability of the conditions of the sand cover development in the Vistulian (Fig. 4). The oldest formations found here (layer 9) are well sorted sands with clearly marked aeolian activity. Aeolian processes indicate that the sands developed in a dry and cold climate. They are dated at 72 600 ± 8700 years B.P (Lub-56) and come from the Early Vistulian. Layers 7—8 testify to the changeable conditions of sheetwash, fluvial and flood water accumulation in the Middle Vistulian. A thick series of bedded medium and fine grained sands (layers 4—6) suggest the comparatively uniform and intensive fluvial accumulation. The sands are dated at 32 500 ± 3900 (Lub-55) and (Lub-54) 29 800 ± 3600 years B.P. (Lub-54). They developed in a humid climate at the beginning of the Late Vistulian. A change of climatic conditions is emphasized by the occurrence of pavement and clay balls. This points to the intensification of aeolian processes as well as to the cutting of the surface. The surface is covered by horizontally bedded fine-grained sands which testifies to the quiet accumulation caused by sheetwash with the participation of aeolian processes. The sandy plain is considerably transformed through aeolian processes on the surface. The intensification of aeolian processes falls in the Late Vistulian, when, according to W o j t a n o w i c z (1968) parabolic dunes developed. A large share of aeolian processes in the development of sand covers in the earlier Vistulian is demonstrated in the studies of D y l i k (1969).

The sandy plain in the Biała Łada and the Tanew valleys have similar granulation (Table 1). Also the heavy mineral compositions of these sands are similar which points to the common origin of the materials. Of the transparent minerals garnet (30—50%) and tourmaline (20—30%) decidedly prevail. A large share have also staurolite (ca. 15%) and epidotes (10—20%). The till in the Niemirów profile departs considerably from the composition described. These are amphiboles (45%) that clearly prevait there. Lower sands in the Tanew profile have a mineral composition similar to the sands lying directly on the till in the Łada profile from Niemirów (Table 2). On the basis of this fact it is possible to believe that these sands come also directly from erosion of morain. The results of the mineral composition studies are consistent with the figures obtained by R a c i n o w s k i (1969).

From the facts presented it results that the sandy plain developed through the fluvial, slope and aeolian reshaping of the older covers during the Central and North Polish Glaciations (S t a r k e l 1972).

Tab. 2. Heavy minerals composition of the terrace sands in the Biała Łada and the Tanew valleys (fraction 0.1—0.2 mm)
Skład minerałów ciężkich piasków terasowych w dolinach Białej Łady i Tanwi (frakcja 0,1—0,2 mm)

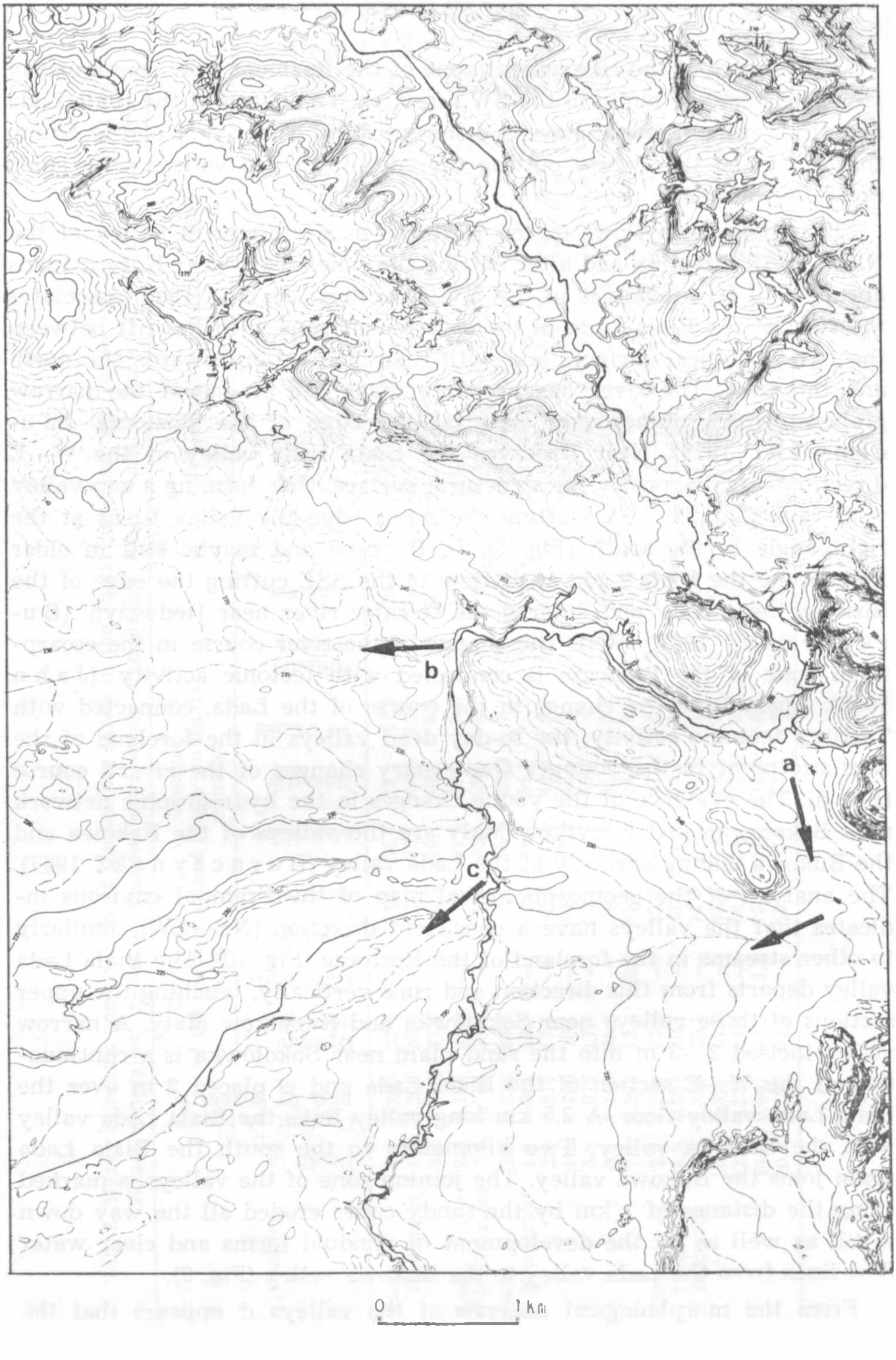
Profiles	Depth m	Content of heavy min. by weight %	Content of the main groups of heavy minerals 100%: Opaque minerals	Glauconite	Transparent minerals	Opaque minerals: Magnetite	Ilmenite	Fe oxides	Transparent minerals=100%: Amphiboles	Epidotes	Pyroxenes	Garnet	Turmaline	Zircon	Rutile	Disthene	Staurolite	Andalusite	Sillimanite	Topaz	Biotite	Others
Łada —	2.5	0.285	27,4	—	72,6	56,4	32,5	11,1	2.9	20.1	+	32,6	16,8	0.9	1.0	1.0	16,5	0,6	1,2	6.2	+	—
Radzięcin	6.0	0.200	28,3	—	71,7	36,7	47,3	16,0	1.2	19.3	0,9	37,4	19,6	2.4	0.3	—	11,1	0,9	0,6	6.0	0.3	—
	8.0	0.406	23,8	—	76,2	46,1	48,4	5,5	1.0	13.4	+	42,2	15,6	2.3	2.9	0.2	13,6	1,5	2,7	4.4	+	0.2
Łada — Wo-	2.0	0.161	27,0	0,5	72,5	61,5	30,3	8,2	+	14.0	0,6	39,6	12,2	3.1	0.6	—	16,2	1,5	0,9	6.7	—	0.3
la Kątecka	6.0	0.760	28,4	—	71,6	68,5	29,4	2,1	+	6.3	+	49,3	11,9	3.9	2.5	1.1	15,5	1,9	2,8	4.2	+	0.6
Łada —	2.2	0.236	27,0	—	73,0	23,9	68,4	7,7	2.5	18.6	—	24,9	24,6	0.2	0.9	0.6	14,5	1,9	2,5	8.8	—	—
Niemirów	1.6	0.061	19,7	—	80,3	44,7	54,0	1,3	0.6	6.5	+	33,2	23,5	1.9	1.6	1.3	12,9	4,5	2,9	10.3	—	0.6
	2.7	0.217	17,6	—	82,4	53,1	44,5	2,4	1.1	11.1	0,8	44,4	17,6	1.3	0.3	0.8	12,4	2,1	1,3	6.8	—	+
	4.0	0.200	19,7	—	80,3	57,9	42,1	+	1.0	16.5	0,6	34,0	21,4	1.2	0.6	0.3	13,3	2,0	1,0	8.1	--	—
	5.5	0.277	17,7	—	82,3	43,9	56,1	+	1.3	13.4	0,7	38,2	18,3	0.6	0.7	1.0	14,7	2,0	3,3	5.2	0.3	0.3
	6.0	0.165	25,5	—	74,5	55,0	41,4	3,6	3.4	26.8	0,6	8,0	27,4	1.2	0.3	1.8	16,0	3,4	2,2	8.6	0.3	—
	7.5	0.292	15,4	2,9	81,7	44,1	54,2	1,7	45.0	15.4	—	18,5	5,8	0.6	1.6	1.0	4,8	0,3	2,2	4.5	0.3	—
Tanew —	2.0	0.256	17,8	—	82,2	48,7	47,4	3,9	2.3	20.2	0,6	28,2	20,5	0.6	1.1	0.6	15,4	1,4	1,4	7.1	0.3	0.3
Huta Ró-	4.0	0.255	30,7	—	69,3	26,4	70,5	3,1	2.4	7.9	—	32,0	18,2	2.7	1.7	0.3	21,3	2,8	3,1	7.6	—	+
żaniecka	5.5	0.356	25,1	—	74,9	37,2	61,1	1,8	+	11.0	0,3	40,6	19,6	1.8	0.3	--	14,2	0,3	1,5	10.4	—	+
	10.5	0.311	17,0	—	83,0	19,1	79,4	1,5	0.3	9.7	0,6	33,2	26,9	1.5	0.9	0.3	14,5	2,1	2,4	7.6	—	—
	12.5	0.172	21,4	—	78,6	24,1	72,3	3,6	0.6	19.1	1,0	19,1	25,3	1.6	2.6	—	16,8	2,3	1,6	10.0	+	—
	14.0	0.441	24,5	0,2	75,3	58,1	35,2	6,7	0.6	16.4	—	36,6	17,7	2.5	1.2	0.3	13,0	0,9	0,6	9.0	0.3	0.6
	20.0	0.227	31,9	—	68,1	37,0	58,9	4,1	4.2	23.1	—	13,5	27,2	0.3	1.0	0.6	18,3	1,9	1,6	8.3	+	—

GAP VALLEYS

Most rivers of the escarpment zone of the Roztocze flow consequently from the Roztocze hump in the SW direction. The rivers of the Biała Łada and the Tanew, though, have a different flow. The rivers of the Szum, the Sopot and the Tanew cutting the edge form gap valleys with steep rapids in the bed.

The Biała Łada flows in the Roztocze in a subsequent valley of the NNW—SSE direction and after cutting the inner scarp near Kąty it turns abruptly to flow along it in the NW direction. Jahn (1956) associates the turn of the Biała Łada in the escarpment zone with the rift between the two structural surfaces and with their inclination towards the north and the west. The river has probably made use of one of the narrow grabens, which numerously occur at the edge of the Roztocze (Muchowski 1979). Near Rzeczyca the Biała Łada valley of the W—E direction cuts diagonally the structural surface, thus forming a gap valley with rapids in the bed. Cutting the outer edge the valley turns at the right angle to the south (Fig. 5). In Pliocene and maybe still in older Pleistocene the Biała Łada river flew to the SSE cutting the edge of the Roztocze near Kąty and entered the Gorajec river near Hedwiżyn (Buraczyński 1967, 1974). The change of the river course in the escarpment zone of the Roztocze is connected with tectonic activity (Jahn 1956). Apart from the change in the course of the Łada, connected with Tertiary tectonic activity, the to-day dead valleys in the foreland of the Roztocze point to the younger Quaternary changes of the river's course (Fig. 5). The evidence of the young changes in the hydrographic network near Sokołówka and Korytków Mały are the valleys of the Rakowa and the Bukowa ending abruptly at the Łada valley (Buraczyński 1967). The analysis of the geomorphological map of the Frampol environs indicates that the valleys have a consistent direction (NE—SW), similarly to other streams in the foreland of the Roztocze (Fig. 10). The Biała Łada valley departs from this direction and runs vertically, touching the upper sections of those valleys near Sokołówka and Korytków Mały. A narrow valley incised 2—3 m into the sand plain near Sokołówka is a continuation of the W—E section of the Biała Łada and is placed 2 m over the Biała Łada valley floor. A 2.5 km long valley links the Biała Łada valley with the Rakowa valley. Two kilometers to the south the Biała Łada again joins the Bukowa valley. The joining zone of the valleys is marked along the distance of 1 km by the sandy cover eroded all the way down to till as well as by the development of residual forms and clear water flow lines from the Łada valley to the Bukowa valley (Fig. 6).

.From the morphological analysis of the valleys it appears that the


a
b
c
0
1 km

Rakowa and the Bukowa valleys are old. They are wide, their valley floor slope is 1‰ and they are slightly incised into the sand plain. The Biała Łada is a young river with an actively developing valley. The valley is narrow, 100—200 m wide, cut in the rock from 2 to 6 m and has a non-levelled gradient. In the gap valley the gradient is 2‰, at the outer edge 5‰ and near Korytków it drops to 1.5‰ (Tab. 3). Below, at more than 5 km from the edge, the gradient increases to 3‰ (Fig. 7).

In the Sandomierz Basin the Biała Łada has a little developed river--basin, stretching in a narrow strip along the valley, which shows that it is a young form. It was developed in a narrow zone through bottom and headward erosion which can be seen from the non-levelled gradient. Through headward erosion the Łada pulled to itself the upper river-basin of the Bukowa.

The hydrographic changes in the escarpment zone of the Roztocze are young which is confirmed by geomorphological studies. Even now flood waters can be moved from the Łada valley to the Bukowa valley. In early Holocene, before the period of intensive cutting of rivers, the Biała Łada river-basin in the Roztocze belonged to the basin of the Bukowa. The Bukowa valley differs in its appearance from the Holocene erosional valleys typical of the Roztocze foreland. One may think that it follows the old water flow lines in the Roztocze from the period of young Pleistocene. This can be seen from the preserved sand covers from the Central Polish Glaciation. In the Great Interglacial and partly during the Central Polish Glaciation the Łada flew in the valley near Kąty, to the SW of the Bukowa. The gap valley was again occupied by the Biała Łada through the structural surface between Kąty and Sokołówka. The Biała Łada rejuvenated the gap valley cut in the Miocene rocks slanting to the west and flew to the Rakowa valley.

The Tanew in the Roztocze flows paralelly to the inner edge in the NW direction and at the outer edge it turns towards the SW. The rivers the Szum and the Sopot cut the Roztocze and foreland in rectilinear valleys of the NE—SW direction. The rivers of the Szum, the Sopot, as well as of the Tanew with the Jeleń and the Łosiniec form on cutting the edge gap valleys with steps in the river-bed (Nowak 1922, Jahn 1956, Maruszczak and Wilgat 1956).

A typical feature of the valleys of the Sopot and the Tanew with

Fig. 5. Changes in the course of the Biała Łada river near Frampol; a — the flow of the Łada near Kąty, b — the issue of the Łada to the Rakowa valley, c — the issue of the Łada to the Bukowa valley

Zmiany biegu Białej Łady koło Frampola, w strefie krawędziowej Roztocza; a — przepływ Łady koło Kątów, b — odpływ Łady do doliny Rakowej, c — odpływ Łady do doliny Bukowej

Tab. 3. Morphometric characteristics of the valleys of the escarpment zone of the Roztocze
Charakterystyka morfometryczna dolin w strefie krawędziowej Roztocza

Valley	Distance from the edge km	Height of terrace absolute m a.s.l.	Height of terrace relative m	Slope terrace ‰	Slope valley floor ‰
Łada	4	240	6	1	2
	0	235	6	10	5
	2	222	2	4	2
	5	218	6	2	1.5
Szum	4	245	4	2	0.7
	0	235	12	11	12.5
	2	220	6	2	3.7
	5	211	3	2	2.5
Sopot	4	267	4	3	2.5
	0	251	18	12	15
	2	240	19	3	5
	5	220	9	3	2.5
Tanew	4	252	4	1	1.5
	2	250	10	1	10
	0	245	20	6	5
	2	237	17	2	3
	5	223	7	2	2.5

the Jeleń and the Łosiniec are terraces on the valley-sides (Fig. 8). The first to notice it was Samsonowicz (1925) who distinguished two terraces in the Sopot valley: the lower one near Hamernia, 25 m high and lowering down the valley to 15 m, and overlooking it, the upper one, about 1 m higher. Maruszczak and Wilgat (1956) did not take these terraces into account while discussing the development of valleys because of inconsiderable height and local character of the surface. Detailed mapping of the valleys showed those three systems of terraces in the shape of continuous laths or isolated shelves (Fig. 7, 9). The lower terrace is an erosive accumulation one 4 m high in the upper part of the gap and 2 m in the lower one. The upper terrace in the Sopot valley is 10 m high in the upper part and 5 m in the lower one, whereas in the Tanew and the Jeleń valley it occurs in small, 8 m high shelves. In the Sopot valley one more terrace can be found in the sections of the profiles d—e (Fig. 9). It is 13—15 m high and lowers to 8 m. It forms small isolated shelves overlooking the higher terrace with the 3—5 m high scarp. Only at the profile e (Fig. 9) the terrace forms a 0.5 km long lath. In consideration of the graphic effect the terraces are not separate on the map.

The discussed rivers deeply cut the sandy terrace, whose slope in the Roztocze area is consistent with the longitudinal profile of the valley. In the Sandomierz Basin the terrace becomes an extensive sand plain. The relative height of the terrace at the outer edge of the Roztocze amounts to 20 m and then drops abruptly down to a few meters (Tab. 3). The terrace profile is inconsistent with the longitudinal profile of the river. The former is convex while the latter is concave (Fig. 7). The river cuts the sand plain incising in a few places even down to the Cretaceous or Tertiary rocks. The longitudinal profile of the rivers of the Szum and the Sopot is dislocated by two lines of steps and in the Tanew valley by three. The fact of the inconsistency of the longitudinal profile of the terrace and the valley-floor Szum was noticed by Buraczyński (1955) and Jahn (1956). The first geomorphological characteristics of the steps of the Tanew and the Jeleń was presented by Chałubińska, Kęsik and Wilgat (1954).

The sand cover in the Roztocze foreland developed under intensive periglacial weathering on the humps of the Roztocze (Jahn 1956). The lack of forest cover caused violent processes of rain-wash and intensive transportation of rubble to river valleys. In the conditions of periglacial climate the rivers flowing from the Roztocze were characterized by great fluctuations of water levels and by great congestion of water with the transported rubble. They were wild rivers of the braided phase and they gradually filled the valleys mainly with bed facies compositions (Falkowski 1971). That is why the sandy plain is built up mostly of sands The material carried out from the Roztocze and accumulated in the foreland was further moved and was affected by aeolian processes which, according to Dylik (1969), were very active in the Vistulian also in the foreland of the Łódź Upland.

The cutting of the valleys into the sand cover took place in connection with the postglacial change of climate and the intensification of geomorphological processes. This caused the change of the wild river phase into the meandering river phase. Falkowski (1971) is of the opinion that the meandering river phase begins only in the Boreal period and according to Kozarski and Rotnicki (1978) it took place much earlier, namely in the late Vistulian. Jahn (1956) as well as Maruszczak and Wilgat (1956) declared themselves for the postglacial cutting of the valleys in the Roztocze. This can be inferred from the young appearance of the valleys of the Szum, Sopot, Tanew with Jeleń and Łosiniec.

The valleys cut the scarp of the Roztocze irregularly. They developed through the undercutting of the valley-sides by the meandering river, which is manifested by the occurrence of terraces in the valleys. In the Late Holocene the valley cuts into a few meters and then forms a terrace through side development. The next erosional period caused a deep cutting. The development of great meanders formed amphitheatres deeply incised in the valley sides. The trace of this activity is the formation of the sand terrace with a cover of muds. In the terrace there are preserved traces of abandoned-loops with peat (Fig. 8).

The development of big meanders can be associated with the Atlantic period. This appears both in the stages of the development of the valley and in the filling of the abandoned-loops with peats. The earliest period of the cutting valley is connected with the destruction of forests and the development of agriculture in the sub-Atlantic period. At that time the valleys cut 2—4 m deep (Fig. 8). Today the rivers are in the meandering phase, but form only small meanders.

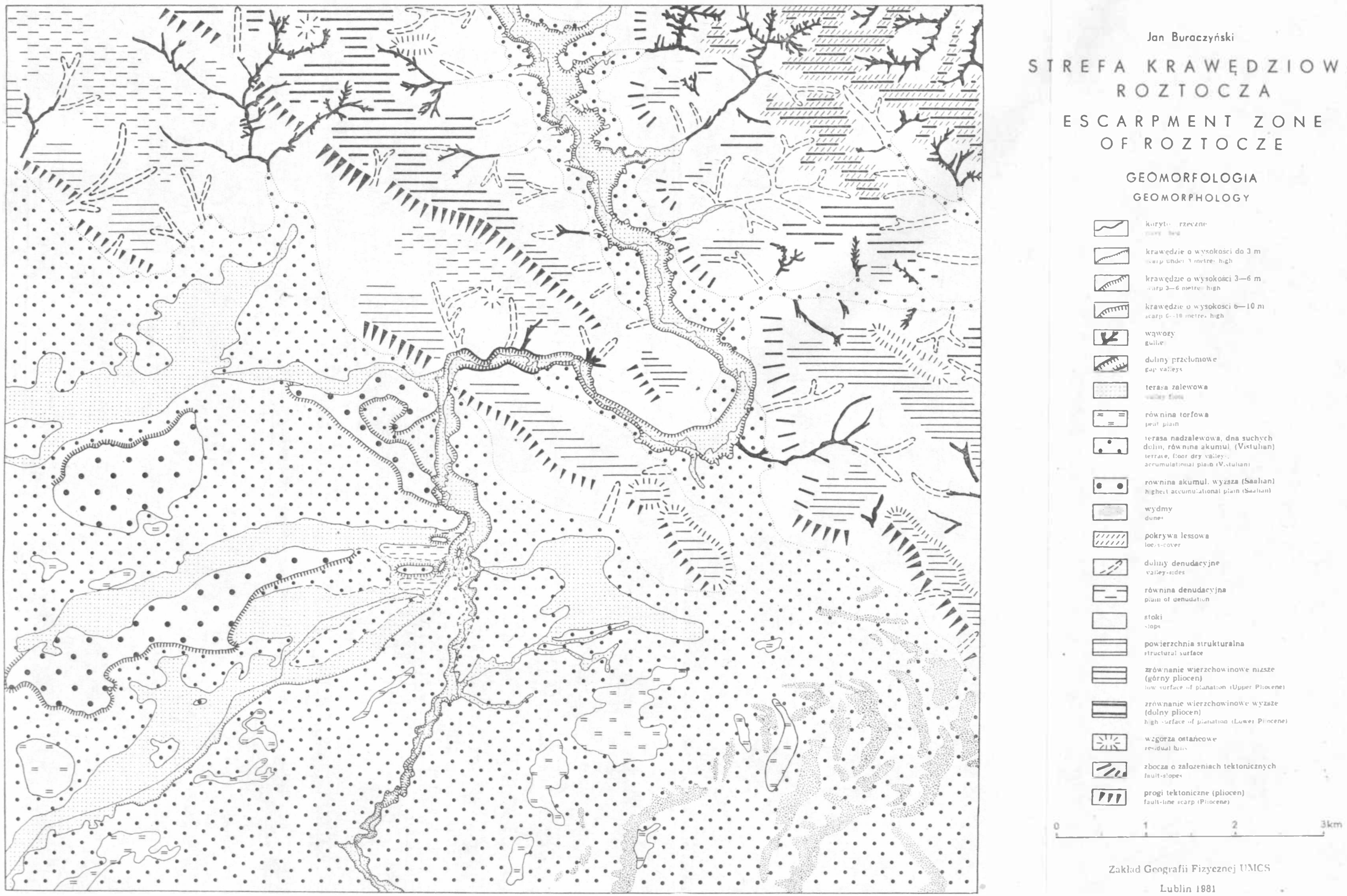
YOUNG QUATERNARY TECTONIC MOVEMENTS

Edges play a great part in the relief of the Roztocze. The southern escarpment is of particular significances as it corresponds with an important tectonic line. It is composed of a number of rectilinear scarps forming a system of steps. The tectonic style of the scarps is made of many faults occurring in the Roztocze foreland under the cover of Quaternary formations and Miocene limestones (Areń 1962, Bielecka 1967, Buraczyński 1967, 1974, Ney 1966, 1969). The connection of the edges with the tectonic lines was noticed a long time ago by many investigators (Pawłowski 1938, Jahn 1956, Maruszczak and Wilgat 1956, Muchowski 1970, Harasimiuk 1980). The connection of the northern escarpment of the Roztocze with the tectonic lines has been discovered only recently. The escarpment can clearly be seen in the Por valley on the line of the fault Zakrzew—Sułów and in the Sołokija valley on the line of the Zamość—Rawa Ruska fault (Buraczyński 1974, 1975).

The main tectonic lines in the Roztocze have the WNW—ESE and the NW—SE directions. The direction perpendicular to the escarpment can also be observed in the Roztocze. These faults cut the area in the escarpment zone into particular blocks. Within the Roztocze hump the blocks are delimited by the asymmetric valley slopes which are the wings of the faults (Fig. 10).

The escarpment zone of the Roztocze developed due to the Miocene tectonics rejuvenated by the tectonics of Pliocene and Quaternary. The tectonic activity in this zone is still active which can be seen from the specific relief. There are gap valleys on the scarp, deeply cut in the rock and having characteristic steps in the river-beds of the Szum, Sopot, Tanew and Jeleń. The dislocated longitudinal profile of those valleys was, according to Nowak (1922), Samsonowicz (1925) and Jahn (1956) the effect of neotectonic processes.

FIG. 6


Jan Buraczyński
STREFA KRAWĘDZIOWA ROZTOCZA
ESCARPMENT ZONE OF ROZTOCZE
GEOMORFOLOGIA
GEOMORPHOLOGY
koryto rzeczne
krawędzie o wysokości do 3 m
scarp under 3 metres high
krawędzie o wysokości 3—6 m
scarp 3—6 metres high
krawędzie o wysokości 6—10 m
scarp 6—10 metres high
wąwozy
gullies
doliny przełomowe
gap valleys
terasa zalewowa
równina torfowa
peat plain
terasa nadzalewowa, dna suchych dolin, równina akumul. (Vistulian)
terrace, floor dry valleys, accumulational plain (Vistulian)
równina akumul. wyższa (Saalian)
highest accumulational plain (Saalian)
wydmy
dunes
pokrywa lessowa
loess-cover
doliny denudacyjne
valley-sides
równina denudacyjna
plain of denudation
stoki
slopes
powierzchnia strukturalna
structural surface
zrównanie wierzchowinowe niższe (górny pliocen)
low surface of planation (Upper Pliocene)
zrównanie wierzchowinowe wyższe (dolny pliocen)
high surface of planation (Lower Pliocene)
wzgórza ostańcowe
residual hills
zbocza o założeniach tektonicznych
fault-slopes
progi tektoniczne (pliocen)
fault-line scarp (Pliocene)
0
1
2
3km
Zakład Geografii Fizycznej UMCS
Lublin 1981

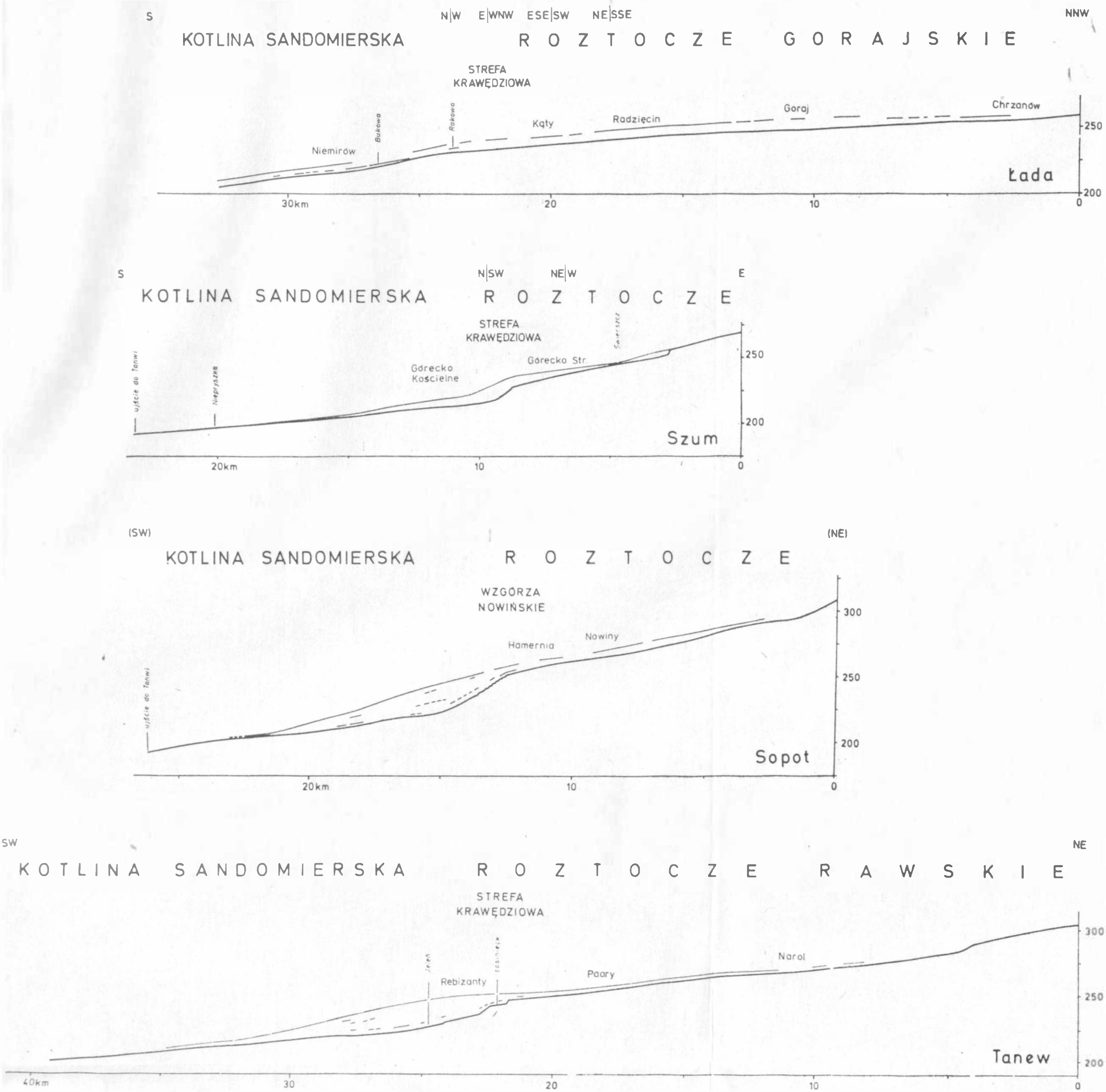


Fig. 7. Longitudinal profiles of the valley floor and of the terrace of some of the river valleys of the Roztocze
Profile podłużne dna doliny i terasy nadzalewowej niektórych dolin rzecznych Roztocza

On the basis of valley investigations in the escarpment zone it was noticed that the rivers crossing the edge of the Roztocze are irregulary cut in the rock. The most strongly cut are such rivers as the Sopot, Tanew and Jeleń, towards the west, however, the cutting valleys decreases which can be seen on the valleys of the Szum and the Łada (Fig. 7).

The valleys cutting the edge of the Roztocze incised in stages which result from the three systems of terraces. The facts presented indicate that incising of valleys in a short section in the escarpment zone is conditioned by the epeirogenetic movements. The incision of valleys in Holocene amounted to 10—20 m that is to say 1—2 mm/year on the average. The greatest incision occurs on the edge line and it is consistent with the

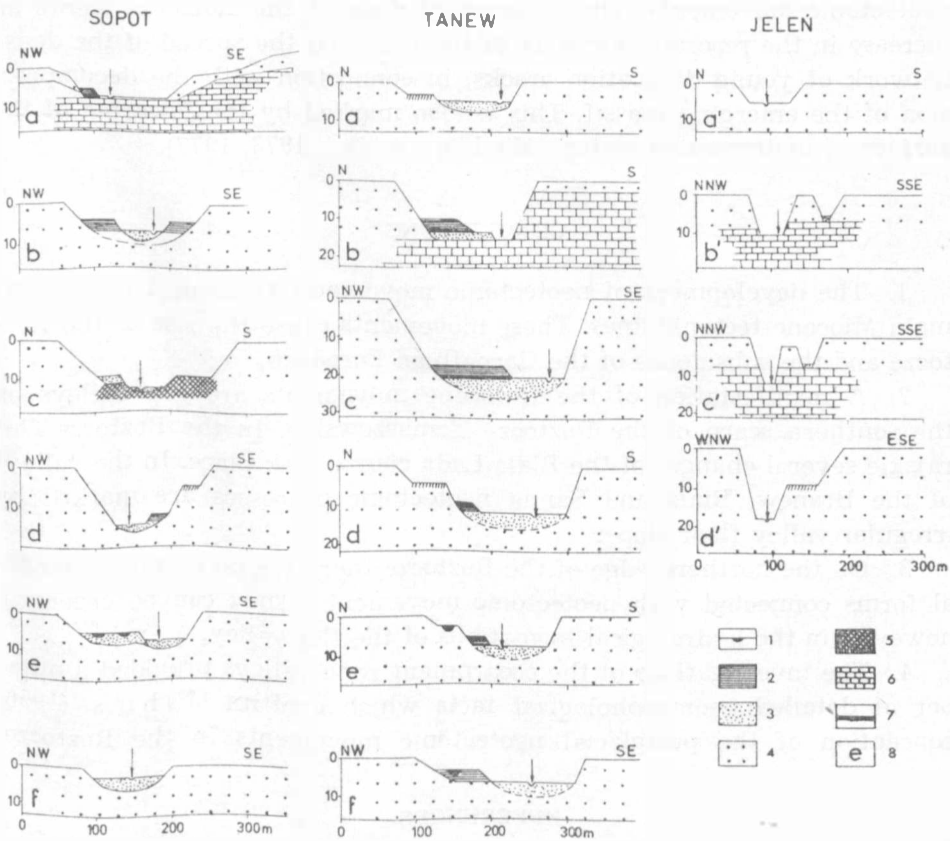


Fig. 8. Geological sections of the Sopot, Tanew and Jeleń valleys; 1 — peats, 2 — silts, 3 — fluvial sands, 4 — terrace sands, 5 — Miocene limestones, 6 — Cretaceous gaize, 7 — terraces, 8 — a—f localization of profiles on Fig. 9

Przekrój geologiczny przez dolinę Sopotu, Tanwi i Jelenia; 1 — torfy, 2 — mady 3 — piaski rzeczne, 4 — piaski terasowe, 5 — wapienie mioceńskie, 6 — geza kredowa, 7 — terasa erozyjna, 8 — a—f lokalizacja profili na ryc. 9

contemporary movements amounting in the Roztocze Tomaszowskie to 1 mm/year. It decreases towards the west, however, so that in the Roztocze Gorajskie it is smaller than 1 mm/year (Kowalski, Liszkowski 1972). The occurrence of three terraces shows that we have to do here with triple manifestations of neotectonic movements — from the Late Vistulian, early Holocene and today.

The results presented confirm Jahn's (1956) conception who on the basis of geomorphological facts associated the incision of the escarpment zone valleys with postglacial movements. For the triple manifestations of neotectonic movements declared themselves Harasimiuk and Henkiel (1975) on the basis of three generations dissication cracks. Also hydrological investigations confirm the manifestations of neotectonic movements. The escarpment zone of the Roztocze shows an increase in the reservoir capacity of the rock and the spread of the dense network of young dissication cracks, in connection with the decompression of the emerging massif. This is also marked by the lowering of the surface of underground water (Malinowski 1973, 1977).

CONCLUSIONS

1. The development of neotectonic movements is connected with the main Miocene tectonic lines. These movements cause the rise of the Roztocze and the subsidence of the Carpathian Foredeep.
2. A manifestation of the Holocene movements are gap valleys on the southern scarp of the Roztocze Tomaszowskie. In the Roztocze Gorajskie several changes of the Biała Łada course took place. In the valleys of the Branew, Biała and Sanna neotectonic processes are marked by irregular valley floor slope.
3. On the northern edge of the Roztocze there are no geomorphological forms connected with neotectonic movements. They can be observed, however, in the hydrological formations of the Por valley.
4. The investigations of the escarpment zone valleys provided a number of detailed geomorphological facts which confirm Jahn's (1956) conception of the postglacial neotectonic movements in the Roztocze.

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FIG. 9

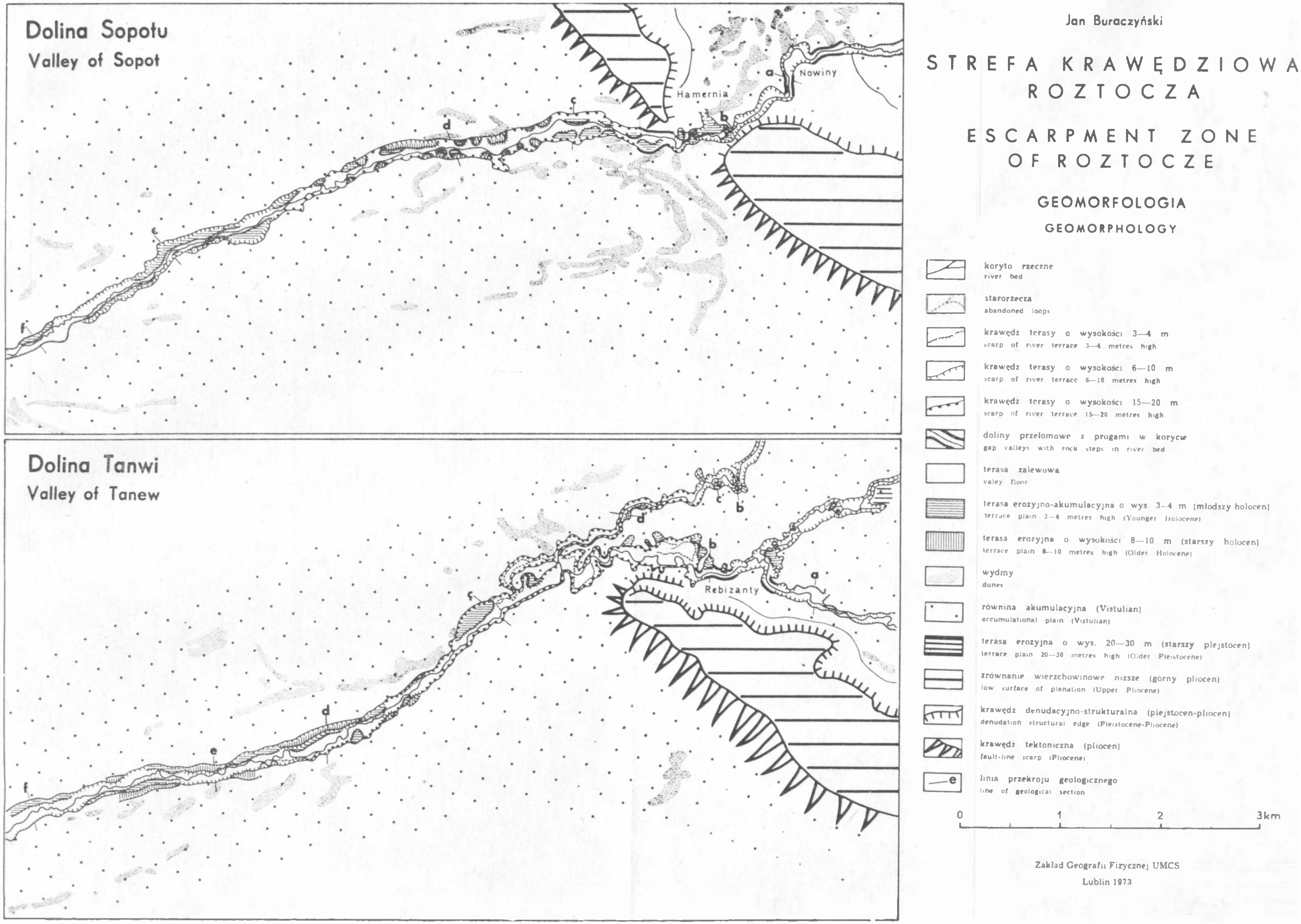
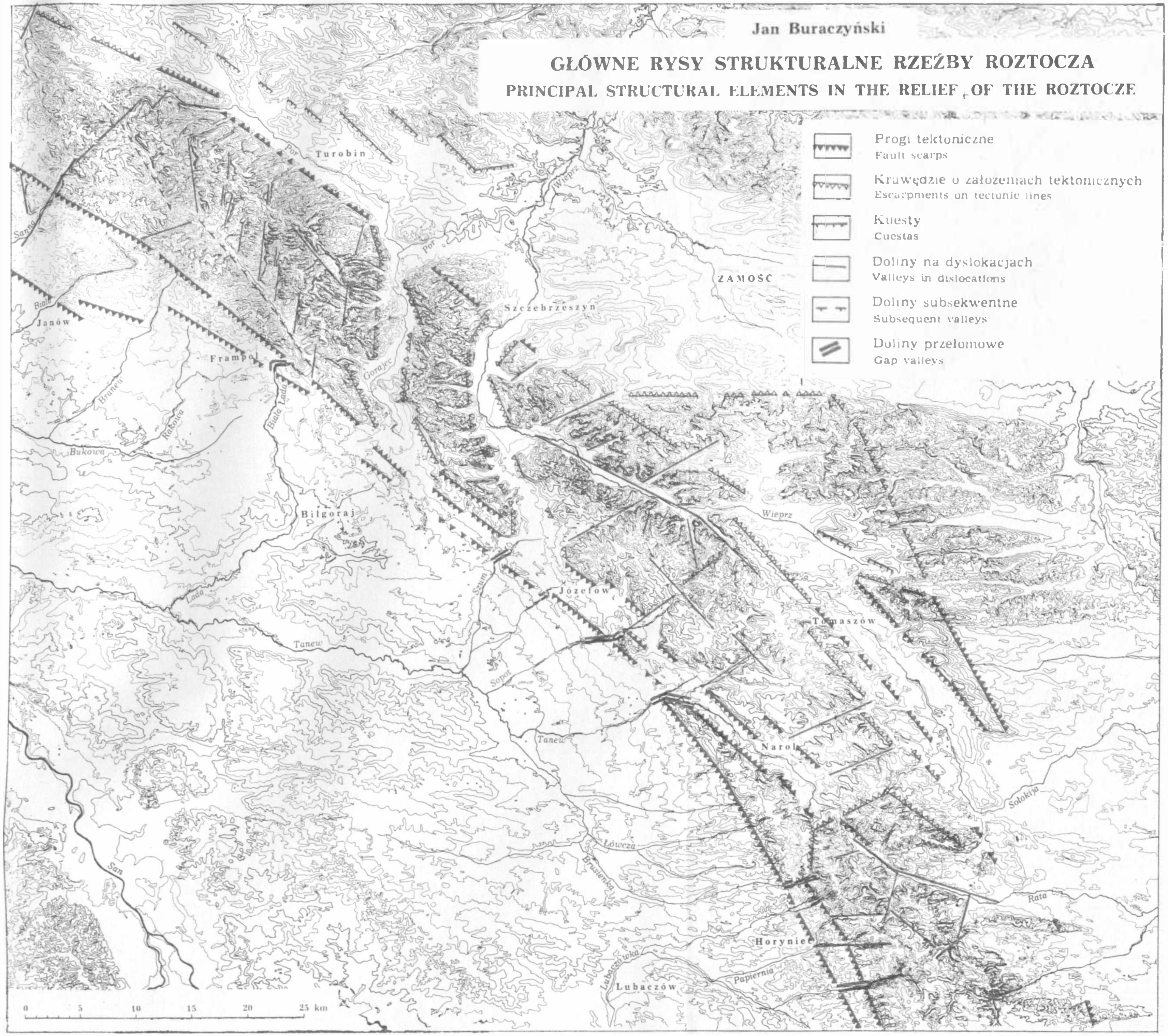

Dolina Sopotu
Valley of Sopot
Hamernia
Nowiny
a
b
c
d
e
f
Dolina Tanwi
Valley of Tanew
Rebizanty
a
b
b
c
d
e
f
Jan Buraczyński
STREFA KRAWĘDZIOWA ROZTOCZA
ESCARPMENT ZONE OF ROZTOCZE
GEOMORFOLOGIA
GEOMORPHOLOGY
koryto rzeczne
river bed
starorzecza
abandoned loops
krawędź terasy o wysokości 3—4 m
scarp of river terrace 3—4 metres high
krawędź terasy o wysokości 6—10 m
scarp of river terrace 6—10 metres high
krawędź terasy o wysokości 15—20 m
scarp of river terrace 15—20 metres high
doliny przełomowe z progami w korycie
gap valleys with rock steps in river bed
terasa zalewowa
valey floor
terasa erozyjno-akumulacyjna o wys. 3—4 m (młodszy holocen)
terrace plain 3—4 metres high (Younger Holocene)
terasa erozyjna o wysokości 8—10 m (starszy holocen)
terrace plain 8—10 metres high (Older Holocene)
wydmy
dunes
równina akumulacyjna (Vistulian)
accumulational plain (Vistulian)
terasa erozyjna o wys. 20—30 m (starszy plejstocen)
terrace plain 20—30 metres high (Older Pleistocene)
zrównanie wierzchowinowe niższe (górny pliocen)
low surface of planation (Upper Pliocene)
krawędź denudacyjno-strukturalna (plejstocen-pliocen)
denudation structural edge (Pleistocene-Pliocene)
krawędź tektoniczna (pliocen)
fault-line scarp (Pliocene)
linia przekroju geologicznego
line of geological section
e
0
1
2
3km
Zakład Geografii Fizycznej UMCS
Lublin 1973

FIG. 10



Jan Buraczyński
GŁÓWNE RYSY STRUKTURALNE RZEŹBY ROZTOCZA
PRINCIPAL STRUCTURAL ELEMENTS IN THE RELIEF OF THE ROZTOCZE
Progi tektoniczne
Fault scarps
Krawędzie o założeniach tektonicznych
Escarpments on tectonic lines
Kuesty
Cuestas
Doliny na dyslokacjach
Valleys in dislocations
Doliny subsekwentne
Subsequent valleys
Doliny przełomowe
Gap valleys
Turobin
Por
Wieprz
ZAMOŚĆ
Szczebrzeszyn
Gorajec
Janów
Biała
Frampol
Branew
Rakowa
Biała Łada
Bukowa
Biłgoraj
Łada
Tanew
Szum
Józefów
Sopot
Tomaszów
Wieprz
Narol
Sołokija
Łówcza
Brusienka
Rata
Horyniec
Lubaczówka
Papiernia
Lubaczów
San
0 5 10 15 20 25 km

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STRESZCZENIE

Strefa krawędziowa Roztocza rozwinęła się na linii starych struktur wgłębnych, w wyniku trzeciorzędowego odmłodzenia uskoków starych i utworzonych uskoków schodowych (NW—SE). Rozdziela ona wydźwignięte struktury od zapadliska przedkarpackiego. Zasadnicze rysy rzeźby wiążą się ze zróżnicowaniem litologicznym osadów mioceńskich oraz ruchów przedplioceńskich. Dalszy rozwój strefy krawędziowej związany jest z tektoniką czwartorzędową.

Powierzchnia trzeciorzędowa w strefie krawędziowej Roztocza ma urozmaiconą rzeźbę, zamaskowaną osadami czwartorzędowymi o miąższości 30—80 m. Najstarsze utwory czwartorzędowe serii rzecznej z interglacjału tegelen stwierdzono w kopalnej dolinie koło Biłgoraja (ryc. 1). Potwierdza to koncepcję Pawłowskiego (1938) o przepływie pra-Sanu przez Roztocze. Najmłodsze utwory czwartorzędowe Kotliny Sandomierskiej tworzy seria piasków grubości 5—20 m. Budują one poziom piaszczysty o złożonej genezie, rozwinięty przez procesy akumulacji rzeczno-rozlewiskowej i stokowej przy współudziale procesów eolicznych (ryc. 3 i 4). Poziom piaszczysty rozwinął się przez przeróbkę starszych pokryw czwartorzędowych w czasie zlodowacenia środkowopolskiego i bałtyckiego.

W strefie krawędziowej Roztocza potoki spływają konsekwentnie ku SW, tworząc na krawędzi odcinki przełomowe z szypotami w korycie. Biała Łada płynie doliną subsekwentną, zmieniając kilkakrotnie kierunek biegu w strefie krawędziowej (ryc. 5). Zmiany kierunków związane z trzeciorzędową działalnością tektoniczną oraz młodoczwartorzędową aktywnością tektoniczną. Biała Łada ma niewyrównany spadek, wąską i głęboką dolinę oraz słabo rozwinięte dorzecze ciągnące się wąskim pasem wzdłuż doliny (tab. 3, ryc. 6). Jest to forma młoda przecinająca poprzecznie współcześnie martwe górne odcinki dolin Bukowej i Rakowej.

Potoki Szumu, Sopotu i Tanwi przecinają krawędź tworząc doliny głęboko wcięte w podłoże skalne. Wcinanie potoków w piaszczysty poziom przebiegało nierównomiernie. Na zboczach utworzyły się trzy terasy erozyjne w postaci wąskich półek (ryc. 7, 8, 9). Natężenie procesów erozyjnych związane było z postglacjalną zmianą klimatu oraz zmianami rzeki roztokowej w meandrującą. Wiek poziomu piaszczystego oraz analiza teras wskazują, że wcięcie rzeki na kilka metrów nastąpiło w starszym holocenie. Największe poszerzenie doliny oraz utworzenie dużych meandrów przypada na okres atlantycki.

Profil podłużny potoków w strefie krawędziowej jest wklęsły, a profil podłużny terasy wypukły. Niezgodność ta dowodzi istnienia ruchów podnoszących na Roztoczu. Wcięcie dolin ograniczone jest do kilkukilometrowej strefy krawędziowej, związane z ruchami podnoszącymi. Wyniosło ono w holocenie 10—20 m, to jest 1—2 mm/rok. Największa głębokość dolin przypada na linię krawędzi i jest zgodna ze współczesnymi ruchami wynoszącymi na Roztoczu Tomaszowskim 1 mm/rok. Występowanie teras erozyjnych wskazuje na trzykrotne przejawy ruchów tektonicznych, ze schyłku Vistulianu, w starszym holocenie i w okresie współczesnym.

РЕЗЮМЕ

Зона краевого уступа Росточа развита на линии древних грубинных структур, в результате третичного омолаживания древних сбросов и формирования ступенчатых сбросов (СЗ—ЮВ). Она разделяет выдвинутые структуры от предкарпатского прогиба. Основные черты рельефа связаны с литологической дифференциацией миоценовых отложений и с движениями происходившими перед плиоценом. Дальнейшее развитие зоны краевого уступа связано с четвертичной тектоникой.

Третичная поверхность в зоне краевого уступа Росточа имеет разнообразный рельеф, замаскированный четвертичными отложениями мощностью в 30—80 м. Самые древние четвертичные отложения аллювиальной серии из межледниковия тегелен найдены в ископаемой долине около г. Билгорай (рис. 1). Это подтверждает мнение Павловского (1938) о том, что пра-Сан переплывал через Росточе. Самые молодые отложения четвертичного периода Сандомирской котловины создают серию песков мощностью 5—20 м. Они слагают песчанистый горизонт сложного генезиса; развитый процессами речно-поводковой и склоновой аккумуляции при участии эоловых процессов (рис. 3 и 4). Песчанистый горизонт (слой) развит путем преобразования древних четвертичных покровов во время среднепольского и балтийского оледенений.

В зоне краевого уступа Росточа потоки имеют консеквентное направление на ЮЗ, образуя на уступе долины прорыва из быстрыцами в руслах. Река Бела Лада течет субсеквентной долиной, изменяя многократно направление в пределах краевого уступа (рис. 5). Изменения направлений связаны с третичной тектоникой, а также с верхнечетвертичной тектонической активностью. Бела Лада имеет невыравненное падение (наклон), узкую и грубокую долину, а также слабо развитый бассейн, простирающийся узким поясом вдоль долины (табл. 3, рис. 6). Это молодая форма поперечно пересекающая мертвые ныне верхние отрезки долин Буковой и Раковой.

Потоки Шуму, Сопоту и Танви пересекают краевой уступ создавая глубокие долины врезанные в скалы основания. Углубление долин потоков происходило этапами. На склонах образовались 3 эрозионные террасы в виде узких полок (рис. 7, 8, 9). Интенсивность эрозионных процессов была связана с послеледниковым изменением климата, а также с преобразованием реки проточной в меандровую. Возраст песчанистого слоя, а также анализ террас указывают, что углубление реки на несколько метров произошло в начале голоцена. Расширение долины и образование больших извилин произошло в атлантическом времени.

Продольный профиль потоков в зоне краевого уступа вогнутый, а продольный профиль террасы — выпуклый. Это несогласие свидетельствует о имевших место на Росточью восходящих движений. Углубление долин ограничено до зоны краевого уступа шириной нескольких километров, подвергавшейся восходящим движениям. Их величины достигли в голоцене 10—20 м, т.е. 1—2 мм/год. Самая большая глубина долин совпадает с линией краевого уступа и стоит в согласии с современными восходящими движениями достигающими в пределах Томашовского Росточа 1 мм/год. Наличие эрозионных террас указывает на трехкратное проявление тектонических движений, в конце Вистуляна, в древнем голоцене и в настоящее время.